Computational and Experimental Investigation of V Shape Heat Sink

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Abstract : The heat sink in the form of extended surfaces or fins are used on various surfaces of different engineering applications, so the study of convective heat transfer and the fluid which moves surrounding is of vital importance. The heat generated in such applications needs to be dissipated to the surrounding atmosphere for safe working and to increase the efficiency of the equipment. The extended surfaces or fins are used for maximum dissipation of heat from the surfaces. Natural convection is used for such applications because it is a reliable and economical heat exchange process. With the creation of the surface boundary layer, the fins over the vertical surface resist the heat exchange from such surfaces. To enhance the heat transfer from vertical surfaces various geometries of fins are used. The present paper reviewed the work done by various researchers in natural convection enhancement over vertical surfaces by using v shape configurations. The various applications of the v shape configurations have been reviewed. The more effective fin geometry used by many researchers is v shape fin configurations. The V shape configurations work as flow disturber and extended surfaces. It is also stated that this v fin configuration may be used in various other applications for natural convection enhancement.

***Index Terms* -** Extended surfaces (fins), Heat sink, Natural convection enhancement, V shape fin

1. INTRODUCTION:

Heat transfer is one of the important phenomena which take place because of a temperature difference between the two bodies. Natural convection is an important mode of heat transfer. It is used in many engineering applications such as I.C. engines cooling, Heating, ventilation, air conditioning, cooling of electronic equipment, transformer cooling, etc. The convection mode of heat transfer depends upon the velocity of the fluid. When velocity is large, the heat transfer coefficient is also large. In natural convection, the fluid flow velocity is very low. Therefore heat transfer coefficient in natural convection is lower than forced convection. For natural convection, external power is not required. Because of this many devices are made to operate on natural convection conditions compared with forced convection. Therefore it is a vital need to study and enhance the natural convection mode of heat transfer. Generally, electronic devices are designed to accommodate a large number of a component in a small space. Because of this more heat is generated and the temperature of electronic devices increases. Therefore, for the safe working of the equipment, the heat generated needs to be dissipated from the devices. Most of the authors have mentioned that the convection mode of heat transfer can be improved by enlarging the heat transfer area and increasing the coefficient of convection heat transfer. The surface area can be increased by utilizing the extended surfaces popularly called a fin. The most common shapes are horizontal, vertical shapes, and the extended surfaces are attached over it for increasing heat transfer. These extended surfaces are used for enhancing heat exchange between the surface and the surrounding convecting fluid. Following are some of the extended surfaces used in practice,

Fig. 1: Extended surfaces

As per the law of convection mode of heat transfer,

$$Q_{conv} = h \times A_S \times (T_S - T_\infty)$$

Where,
h = coefficient of convective heat transfer,
A_S = surface area of heat transfer,
T_S = surface temperature,
T_∞ = surrounding fluid temperature.

The various applications of fin materials are cooling of internal combustion engines, automobile radiators, air-cooled compressors, fin transformers, electronic systems, and electric motor bodies.

In the analysis of fin various parameters like fin efficiency, fin effectiveness, fin length, fin height, fin spacing are used. Following are some of the fin shapes like annular, tapered, rectangular, trapezoidal, v shape fins for natural convection enhancement,

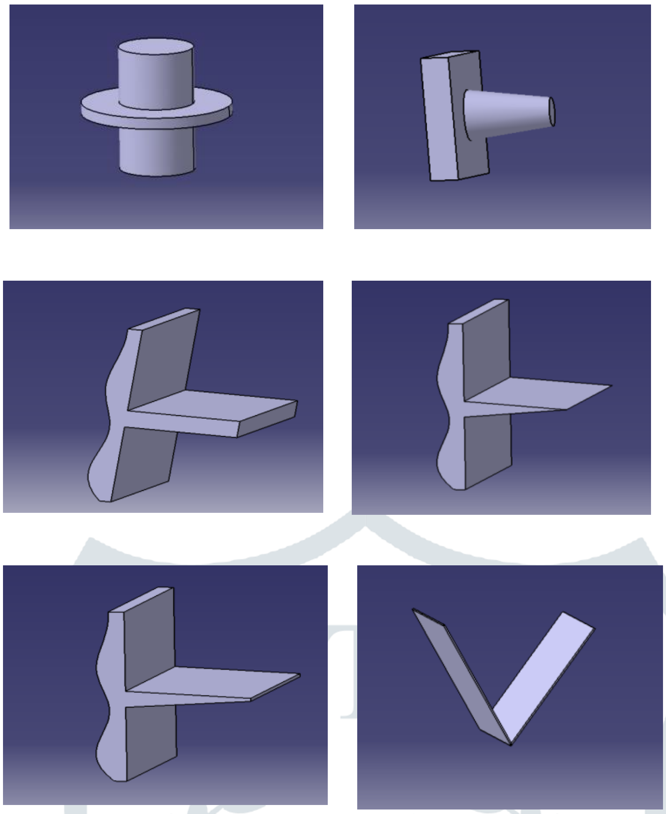

Fig. 2: Various fin geometries used for natural convection

2. Literature Review:

Misumi et al did experimentation on the vertical plate with v shape fin and water as the surrounding medium and found maximum convective heat transfer rate with such geometry of the extended surface.[1]

Eldabadkar et al in their numerical analysis used one v shape extended surface of various included angles with air as the neighboring fluid. They kept the surface area the same for various configurations and found the best enhancement in natural convection for 90^0 extended surfaces. The surface area for different configurations is shown below,

Table 1: A Surface area for computational setup [2]

	Area of a Surface plate in Sq. meter			
	Vertical plane surface	**Horizontal fin over a plain surface**	**Vertical fin over a vertical surface**	**V shape fin Over vertical surface**
Fin Height in meter	-	0.03	0.03	0.03
Area of base surface	0.18	0.18	0.18	0.18
Area of fin	-	0.036	0.036	0.036
Total area	0.18	0.216	0.216	0.216

They also compared numerical and experimental results and obtained acceptable minimum variations. The optimum fin geometry study with configuration is suggested and required. It was found that in the downstream region of such configurations (low-pressure zone) were created helped in better heat transfer rate.[2] Following geometric model was used for computational analysis,

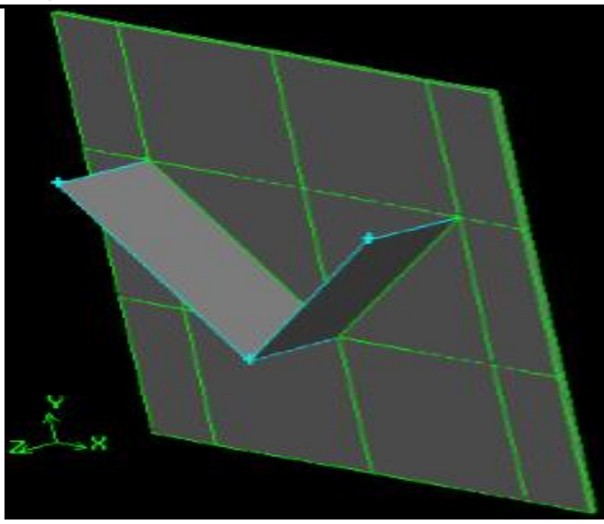

Fig. 3: Base surface with V shape extended projections[2]

Sujan et al experimented on c shape and v shape fin array for line and staggered arrangement with same heat input and increase in Reynold number. The result obtained shows C shape staggered arrangement has better-forced convection enhancement.[3]

Mohammad Naserian et al have done the computational and experimental study for v shape extended surface of 900 include angle for different row spacing and row number keeping other fin parameters constant. The specialty of v type fin in this work is split fin. Finally, optimum fin parameters are obtained for better cooling. It was also found that that the reason behind the minimum heat transfer coefficient is the creation of a surface boundary layer over surfaces.[4]

Shah et al examined the performance of heat transfer enhancement with horizontal fin, split fin, and v shape fin geometries. They used different heat inputs for experimental work and found that split fin patterns better for forced convection mode of heat transfer. For the successful conduction of this works some electrical instruments are used.[5]

S. K. Hingangave et al presented a review paper on an experimental investigation of an inclined aluminum vertical surface with v shape fin attached under the condition of natural convection heat transfer. They used aluminum material as a vertical surface for analysis purposes. They have explained that the vertical fin shapes are inefficient, ineffective heat transfer from the vertical surfaces and v shape fin works as flow turbulator and extended surface also increases heat transfer than surface enlargement ratio.[6]

Shyam Kumar et al examined the thermal performance of solar absorber plate by using v shape fin in natural sunlight The black coated aluminum absorber plate of area 1.4 m2 is placed in the mid position of duct covered with an acrylic glass.it is found that heat gain in v shape plate is higher than a flat plate. The plates were tested for $30^{0},60^{0},45^{0}$. Thermal efficiency is highest for 60° followed by 30° flat plate and 45°. The thermal efficiency data obtained is shown below,

Table 2: Thermal efficiency data [7]

m	Flat plate	30^{0}	60^{0}	90^{0}
0.025	0.47	0.5	0.39	0.54
0.021	0.3	0.47	0.33	0.49
0.018	036	0.44	0.27	0.42
0.014	0.27	0.32	0.21	0.31
0.01	0.26	0.2	0.19	0.22
0.007	0.12	0.16	0.13	0.15

The thermal performance was increased for higher degree v shape fin because of a generation of turbulence. [7]

Sable et al investigated the use of a v shape configuration array on vertical surfaces with surrounding fluid as air and found that in comparison to traditional vertical rectangular extended surfaces the v shape configuration array gives more heat transfer coefficient. They identified that v shape fin configuration acts flow disturber and extended surface. Because of the formation of a heat resistant layer over the vertical surface, it avoids the heat exchange between the vertical surface and surrounding convecting fluid. By taking the extended surface height from 20mm to 38mm experimental work is completed for different configurations of a vertical surface with a vertical rectangular surface, bottom spacing, v shape configuration array as shown below,[8]

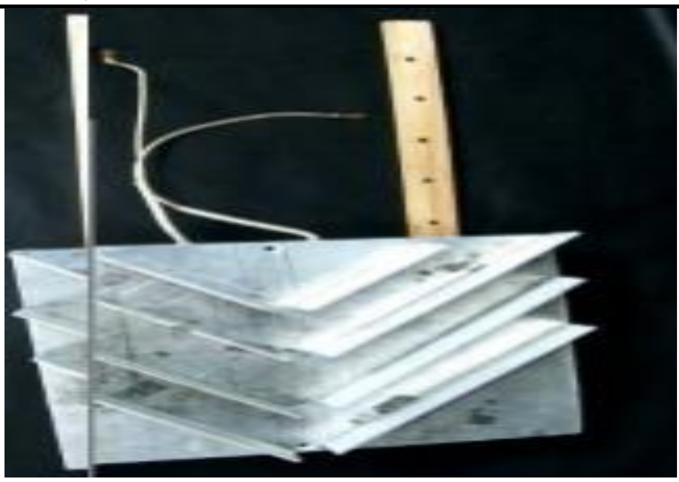

Fig. 4: V shape extended surface configuration with spacing [8]

Fig.5: V shape configuration with extended surface height [8]

It is also found that the base value of the coefficient of heat transfer for v shape configuration is more than all other fin configurations and an average value of the coefficient of heat transfer for plain surface plate is higher than all other fin configurations as shown below,

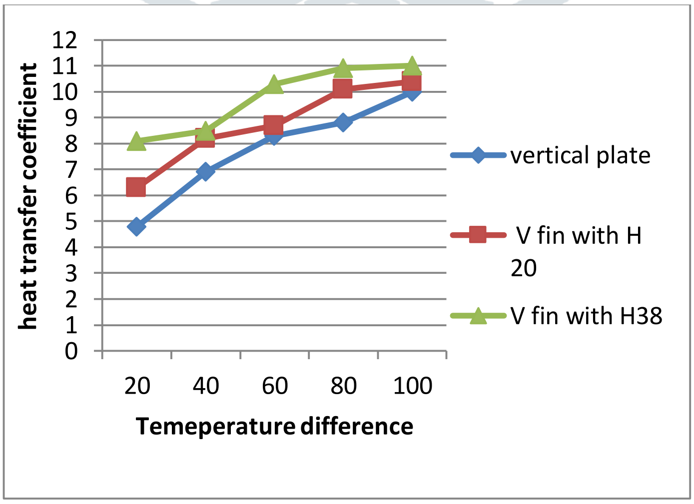

Fig. 6: Variation of base heat transfer coefficient Vs temperature difference[8]

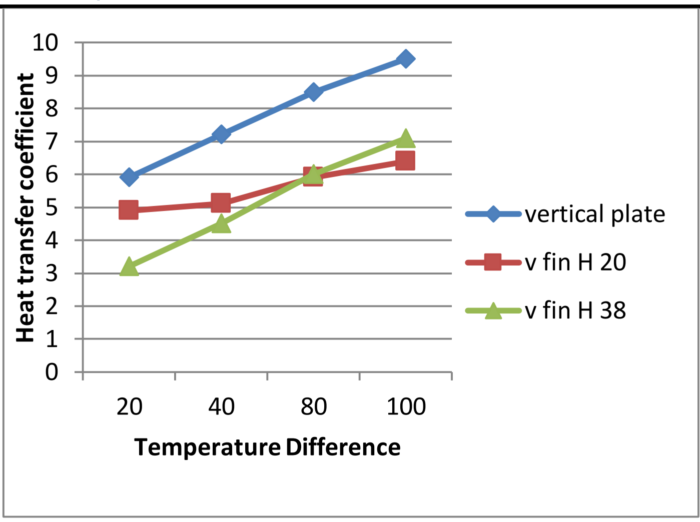

Fig.7: Variation of average heat transfer coefficient Vs temperature difference[8]

Jabir S.K. investigated numerically natural convection heat transfer from horizontal rectangular fins with varying heat flux. The mathematical model is solved using Comsol (5.0). The empirical correlation for the overall Nusselt number and rayleigh number is also obtained and found that that Nusselt number is a function of Rayleigh number.[9]

S.A.Wani et al did experimentation on natural convection study on surfaces with a horizontal rectangular extended surface, V shape with the blackened surface. Apex in Downwards configuration of V-Fins, the value of average heat transfer coefficient was in between 7 to 8 W/m^2 K. This value is largest for any other extended surface configurations. It was concluded the V-shape extended surface which is in downward directions obtained a good performance than the Plain vertical surface, Vertical surface with Horizontal Fins. The values of coefficient of heat transfer obtained are shown below,

Table 3: Heat transfer coefficient with heat input [10]

NO.	**Heat in flow in watt**	**Average heat transfer coefficient (W/m2k)**		
		Vertical blackened surface with horizontal fins	**Vertical blackened surface with horizontal extended surface**	**Vertical blackened surface with v shape extended surface**
1	50	709	2.69	7.19
2	75	7.24	3.60	7.29
3	100	7.39	4.55	7.48

It also increases with an increase in heat input and an increase in the temperature difference. It was also stated that the v fin configuration gives better performance since it shows the nature of the flow disturber. [10]

Sina Lohrasbi et al did the optimization of latent heat thermal energy storage system assisted by v fin during the discharge process. By observation of extended surface, the structure gets the maximum energy capacity and solidification expedition. The solidification expedition is obtained by increasing thickness with heat transfer rise. [11]

S.A. Wani et al discussed the efforts of earlier researchers in the field of heat exchange enhancement and gave hint for further investigations. They also review the convection mode of heat transfer by using fins also found that v shape structures are effective. They suggested the use of a blackened surface fin for increasing the radiative heat transfer. [12]

Monika Solanki et al conducted CFD analysis of heat sink with v shape fin array by using computational fluid dynamics software ANSYS 14.0. The simulation is done for different heat inputs. For the simulation, they used v fin with a staggered arrangement and concluded that the V the models having same ambient air velocity, having same heater input and constant other parameters like surface area and material. The V fin of 35-45 mm gives the maximum coefficient of heat transfer thus gives maximum heat transfer rate.[13] The results of descending model with extended surfaces are shown below,

Table 4: Results of Descending model with extended surfaces [13]

Heat Input, (Watt)	Room Temp in kelvin	Fins Temp., in kelvin	Convective mode of Heat Transfer Coefficient, W/ m2K	Nusselt Number
100	300	317	17.2	521.66
150	300	323	18.8	568.75
200	300	330	19.6	592.91
250	300	335	20.6	622.79

Kai Zhang et al did the experimental study on w shape fin configuration on a vertical plate and found that w fin configuration achieves a maximum cooling effect and of the larger temperature decrease of four and a half degrees, around three degrees of average temp. drop. Here two v fin configurations are joined and one w fin configuration is formed. They have also compared parallel fin heat sink with w fin heat sinks. The experimental setup used is shown below,

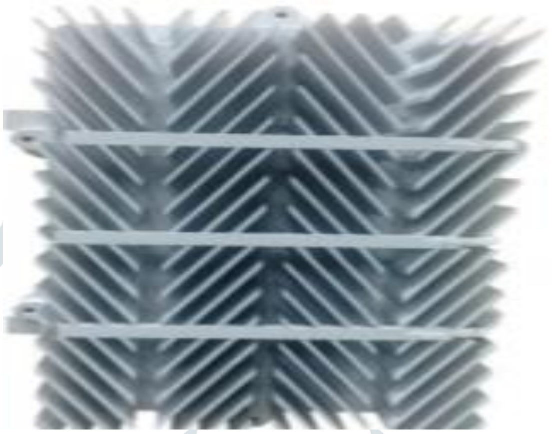

Fig. 8: W (v fin) type heat sink[14]

Numerical analysis is also carried out for validation of experimental results and fluid flow nature and temperature variations of w shape heat sink are studied. The temperature variation over the computational model is shown below,

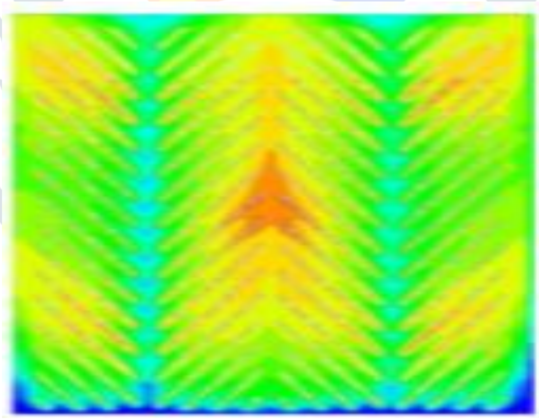

Fig. 9: Computational Model of w (v fin) type heat sink showing temperature distribution [14]

The inflow air method is transformed compared to parallel surface fins. When the air inflow in the perpendicular way of the substrate is raised, the drop in temperature between the fin and inflow of air is also increased that reduced the thermal resistance. [14]

3. FUTURE SCOPE:

In the coming future, the v shape fin configurations can be used to enhance the convection mode of heat transfer on horizontal, vertical, inclined, and cylindrical shapes. There is a large span to work in this area. Testing and formation of some new correlation may be done. New or some advanced materials may be used to form the extended surfaces to increase the natural convection mode of heat transfer.

4. CONCLUSION:

As heat dissipation is used in a variety of engineering applications and also the fluid mover is not used, so the natural convection heat transfer enhancement is very important. This review describes the importance of the geometry of extended surfaces (fins), the nature of a surface, its inclination, the distribution of temperature on the shapes, and the fluid properties. From the literature review, it is also found that various authors have did their contribution in natural convection enhancement using v shape fins over different surfaces and concluded that v shape configurations are best effective for heat transfer. The v shape fin configurations work as extended surfaces and flow disturber. V fin configurations also eliminate the effect of boundary layer development on the surface. We are sure that, this review work will be helpful for further research on the enhancement of natural convection over various surfaces by using v shape configurations.

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